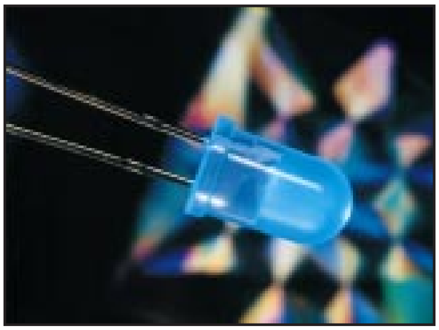
SILICON CARBIDE IS READY FOR PRIME TIME

Process technology for low-cost, low-defect silicon carbide is enabling cutting-edge electronic devices, and paving the way for other novel components.

The physical and electronic properties of silicon carbide (SiC) make it an attractive semiconductor material for the 21st century. For example, SiC's wide energy bandgap will enable the creation of new electronic devices that can operate in extremely high temperatures or emit and detect short wavelength light. However, improvements in SiC crystal growth and device fabrication processes are needed before these devices can be scaled up and incorporated into electronic systems.



■ Cree's scientists created a light-emitting diode (pictured above) that emits an intense, brilliant blue light when an electrical current is applied.

Cree Research, Inc. (Durham, CA), has put to use new process technology that overcomes many of the basic technical obstacles that have blocked the commercialization of SiC semiconductors. Cree's technology significantly reduces the defect density and cost of the company's SiC wafers, making the material commercially viable for some uses and nearly so for many others. In addition, it is enabling the company to develop a wide range of advanced semiconductor electronic products, such as blue light-emitting diodes (LEDs) and displays.

Many of Cree's process innovations can be traced to the SiC research it performed under several BMDO contracts. BMDO's original vision of space-based systems required radiation-hardened electronics. This hardening property allays the fear of space radiation degrading or disrupting the operation of electronic devices and components on monitoring, tracking, and even weapons-carrying satellites.

■ Lab-created moissanite gemstones (pictured above) are being marketed to the jewelry industry as a substitute for diamonds.

Colorful splash. The company's first commercial products using this SiC process technology are its blue LEDs. Cree currently sells LEDs to manufacturers who incorporate them into LED lamps. For example, Cree's largest customer, Siemans A.G., is using the blue LED for automobile dashboard lighting. Other commercial applications for blue LEDs include large-scale flat-panel displays, color recognition sensors, color slide and film scanners, and digital color photographic printers. As production costs decrease and volume increases, Cree expects to see broader applications emerge for its blue LEDs.

Another commercial product that benefits from Cree's SiC process technology is the Real Color Module™, a device only three inches thick and loaded with LEDs capable of representing the entire color spectrum. The module provides a low-cost and effective way of displaying text messages, which can be easily changed and updated. Near-term potential applications for the module include gaming, casinos, and advertising displays. Recently, Rainbow Vision Company, Ltd., placed Cree's largest one-time order for 800 Real Color Modules. The devices will be used in a live-action replay board for a sports arena.

In addition to these commercial products, Cree has developed a highly successful business using the process technology to manufacture and supply SiC wafers to corporate, government, and university programs. These customers are, in turn, using these products to develop new high-frequency, high-power, and high-temperature devices. Cree recently concluded an agreement to supply Asea Brown Boveri AB, a manufacturer of SiC power semiconductors, with SiC wafers worth a total of $2.4 million.

On the horizon. Cree is banking on the future potential of its SiC process technology by investigating potential business opportunities in blue lasers, microwave devices, and power devices. For example, Cree's blue LED research and development efforts have paved the way for developing a blue laser. Recently, the company validated the use of SiC as a viable substrate for blue lasers by showing a pulsed and continuous wave laser operation. Blue lasers are expected to enable a dramatic increase in optical data storage capacity. Because of the blue laser's short wavelength, it could increase storage capacity fourfold.

To generate a new level of commercial interest in SiC microwave devices, Cree recently demonstrated a high-powered SiC metal-semiconductor field-effect transistor. Silicon-based microwave products capable of operating at higher power levels are currently available, but these are typically multiple-chip packages. SiC microwave transistors, if packaged in a single-chip product, could offer power levels substantially higher than other solid-state products now on the market.

And on a completely different track, Cree serendipitously created a sparkling new business opportunity for colorless SiC crystals. While improving the SiC growth process, Cree's scientists accidentally synthesized clear moissanite, a carbon-based mineral that has physical characteristics closer to diamond than any other known gemstone material. Recognizing this material could be easily mistaken for diamond, Cree formed a business alliance with C3, Inc., to explore the jewelry market. Using Cree's colorless SiC crystals, C3 is now, or will soon be, marketing moissanite gemstones through jewelry retailers in 47 U.S. cities.

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What Does It Mean to You?

Low-cost, defect-free silicon carbide is enabling many commercial products, from full-color displays and moving message signs to high-power radio frequency and microwave transmitters.

What Does It Mean to Our Nation?

Silicon carbide technology can lead to more efficient power transistors for lighting, heating, and air conditioning products, which could reduce national energy consumption and, in turn, reduce pollution resulting from energy production.

Tech Trivia

When incandescent lights for the display on the Goodyear blimp Spirit of Akron were replaced with brighter light-emitting diodes, what was the result?

A. A decrease of 250 pounds
B. A decrease of 500 pounds
C. An increase of 250 pounds
D. An increase of 500 pounds

For the answer, see page 74.